Clifty Creek Station

Madison, Indiana

Evaluation of Compliance with the 1-hour NAAQS for SO_2

September 17, 2015

Conducted by:

Steven Klafka, P.E., BCEE

Wingra Engineering, S.C.

Madison, Wisconsin

1. Introduction

Wingra Engineering, S.C. was hired by Sierra Club to conduct an air modeling impact analysis to help the U.S. Environmental Protection Agency (USEPA), state and local air agencies identify facilities that are likely causing exceedances of the 1-hour sulfur dioxide (SO_2) national ambient air quality standard (NAAQS). This document describes the results and procedures for an evaluation conducted for the Clifty Creek Station located in Madison, Indiana.

To ensure the modeling analysis reflected the cumulative concentration of SO_2 emissions, it included emissions from the following additional sources of SO_2, which are located within 50 kilometers of the Clifty Creek Station:

- Trimble County Generating Station – Bedford, Kentucky
- Ghent Generating Station – Ghent, Kentucky

The dispersion modeling analysis predicted ambient air concentrations for comparison with the 1-hour SO_2 NAAQS. The modeling was performed using the most recent version of AERMOD, AERMET, and AERMINUTE, with data provided to Sierra Club by regulatory air agencies or obtained through other publicly-available sources as documented below. The analysis was conducted in adherence to all available USEPA guidance for evaluating source impacts on attainment of the 1-hour SO_2 NAAQS via aerial dispersion modeling, including the AERMOD Implementation Guide; USEPA's Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010; modeling guidance promulgated by USEPA in Appendix W to 40 CFR Part 51; USEPA's March 2011 Modeling Guidance for SO_2 NAAQS Designations;[1] and USEPA's December 2013 SO_2 NAAQS Designations Technical Assistance Document.[2]

2. Compliance with the 1-hour SO_2 NAAQS

2.1 1-hour SO_2 NAAQS

The 1-hour SO_2 NAAQS takes the form of a three-year average of the 99th-percentile of the annual distribution of daily maximum 1-hour concentrations, which cannot exceed 75 parts per billion (ppb).[3] Compliance with this standard was verified using USEPA's AERMOD air dispersion model, which produces air concentrations in units of $\mu g/m^3$. The 1-hour SO_2 NAAQS of 75 ppb equals 196.2 $\mu g/m^3$, and this is the value used for determining whether modeled impacts exceed the

[1] http://www.epa.gov/scram001/so2_modeling_guidance.htm
[2] http://www.epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf
[3] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010.

NAAQS.[4] The 99th-percentile of the annual distribution of daily maximum 1-hour concentrations corresponds to the fourth-highest value at each receptor for a given year.

2.2 Modeling Results

Modeling results for Clifty Creek, Trimble County, and Ghent Generating Stations are summarized in Table 1. It was determined that based on either current allowable emissions or measured actual emissions, the Clifty Creek Station is estimated to create downwind SO_2 concentrations which exceed the 1-hour NAAQS.

More specifically, the modeling results presented in Table 1, show exceedances of the NAAQS by the plant's allowable and actual emissions. "Allowable" is the peak emission rate from each unit as approved by the current air quality operation permit for the facility. "Actual" are the measured emissions for each hour between January 1, 2012 and December 31, 2014 as taken from USEPA *Air Markets Program Data*.[5]

In addition, the emissions from the Trimble County and Ghent Generating Stations, both individually and cumulatively, significantly contribute to the ambient SO2 concentration in the area impacted by Clifty Creek Generating Station.

Air quality impacts in Indiana are based on a background concentration of 41.7 μg/m^3. This is the 2011-13 design value for Vanderburgh County, Indiana - the lowest measured background concentration in the state. This is the most recently available design value. See Section 5 for further discussion of the background concentrations used for this analysis.

Table 1 - SO_2 Modeling Results for Clifty Creek Station Modeling Analysis

Emission Rates	Averaging Period	99th Percentile 1-hour Daily Maximum (μg/m^3)				Complies with NAAQS?
		Impact	Background	Total	NAAQS	
Allowable	Clifty Creek	1,681.8	47.1	1,728.9	196.2	No
Actual		234.3	47.1	281.4	196.2	No
Actual	Trimble	33.5	47.1	80.6	196.2	Yes
Actual	Ghent	76.0	47.1	123.1	196.2	Yes
Actual	All Plants	236.5	47.1	283.6	196.2	No

[4] The ppb to μg/m^3 conversion is found in the source code to AERMOD v. 14134, subroutine Modules. The conversion calculation is 75/0.3823 = 196.2 μg/m^3.
[5] http://ampd.epa.gov/ampd/

The emissions used for the modeling analysis are summarized in Table 2.

Table 2 - Modeled SO_2 Emissions from Clifty Creek Station [6]

Stack ID	Unit ID	Allowable Emissions 30-day Average (lbs/hr)
S13	Unit 1	14,054.9
	Unit 2	14,054.9
	Unit 3	14,054.9
	Subtotal	42,164.7
S46	Unit 4	14,054.9
	Unit 5	14,054.9
	Unit 6	14,054.9
	Subtotal	42,164.7
Facility	Total	84,329.4

Based on the modeling results, Table 3 provides the emission reductions from current allowable rates necessary to achieve compliance with the 1-hour NAAQS. This assumes a one-hour averaging period for the emission rate and that the emission rate is binding at all times. However, given the conservative aspects of this modeling protocol, it is extremely likely that this limit is too high to protect the NAAQS. For example, startup or shutdown periods were not evaluated. During these periods, decreased gas velocities and temperatures may lead to greater ambient impacts at ground level. Further, the hypothetical emission limitation in Table 3 would allow Clifty Creek Station to consume the entire NAAQS, leaving little to no room for any other source of SO_2 in the area. No margin of safety has been included in the hypothetical emission limitation.

Table 3 - Required Emission Reductions from the Clifty Creek Generating Station for Compliance with the 1-hour NAAQS for SO_2

Acceptable Impact (NAAQS - Background) 99th Percentile 1-hour Daily Max ($\mu g/m^3$)	Required Total Facility Reduction Based on Allowable Emissions (%)	Required Total Facility Emission Rate (lbs/hr)	Required Total Facility 1-hour Average Emission Rate (lbs/mmbtu)
149.1	91%	7,476.2	0.67

Predicted exceedances of the 1-hour NAAQS for SO_2 based on allowable emissions extend throughout the region to a maximum distance of 50 kilometers.

[6] Indiana Department of Environmental Management,Part 70 Operating Permit Renewal, Operation Permit No. T077-29920-00001, July 7, 2001. Allowable emissions for Units 1 to 6 are 7.52 lbs per million BTU.

Figure 1 shows the extent of NAAQS violations based on allowable emissions from Clifty Creek Generating Station.

Figure 2 shows the extent of NAAQS violations based on actual hourly emissions from all sources.

2.3 Conservative Modeling Assumptions

A dispersion modeling analysis requires the selection of numerous parameters which affect the predicted concentrations. For the enclosed analysis, several parameters were selected which under-predict facility impacts.

Assumptions used in this modeling analysis which likely under-estimate concentrations include the following:

- Allowable emissions are based on a limitation with an averaging period which is greater than the 1-hour average used for the SO_2 air quality standard. Emissions and impacts during any 1-hour period may be higher than assumed for the modeling analysis.

- No consideration of facility operation at less than 100% load. Stack parameters such as exit flow rate and temperature are typically lower at less than full load, reducing pollutant dispersion and increasing predicted air quality impacts.

- No consideration of building or structure downwash. These downwash effects typically increase predicted concentrations near the facility.

- Except for Trimble County and Ghent Generating Stations, no consideration of off-site sources. Any other sources of SO_2 will increase the predicted impacts.

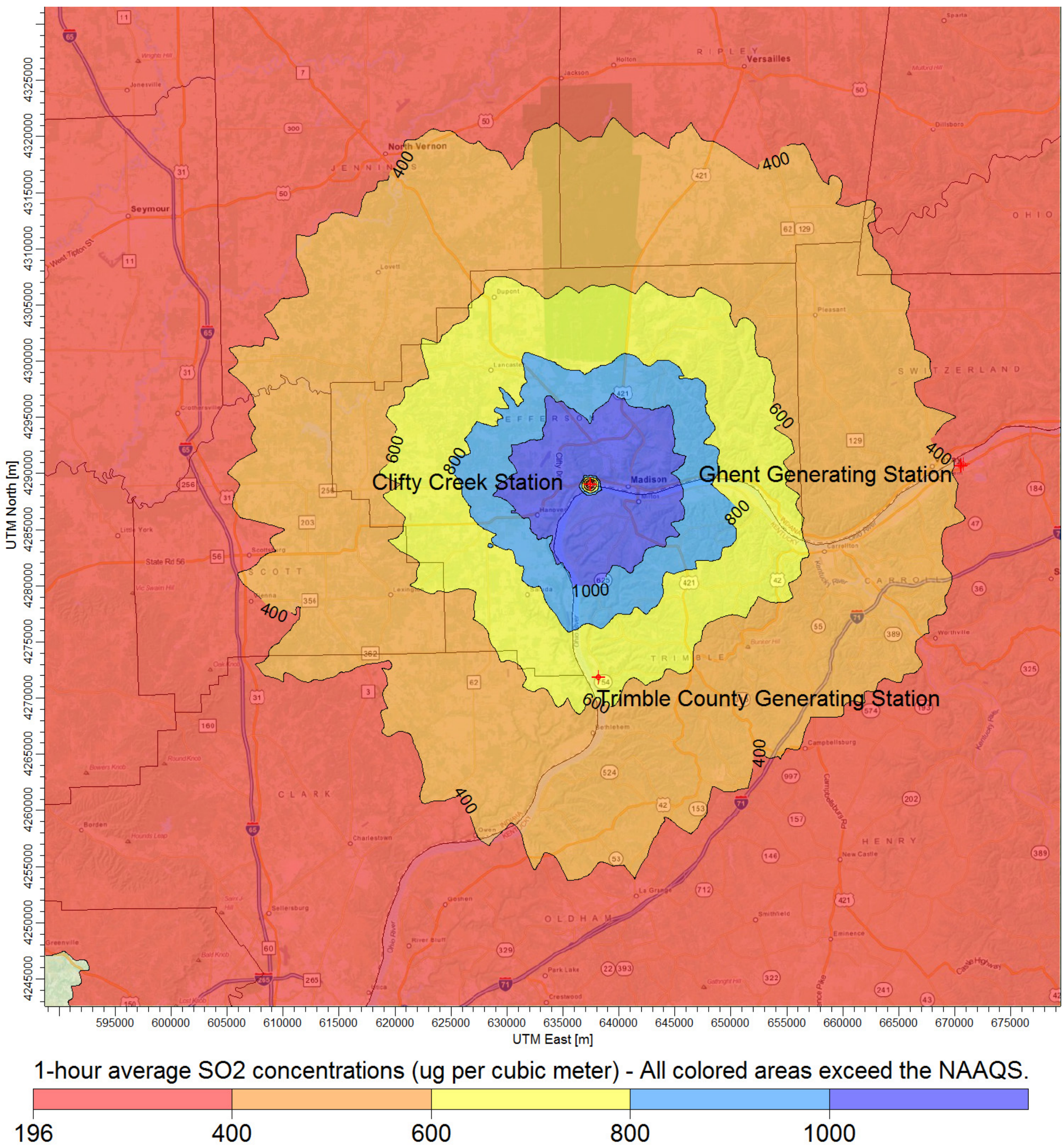

Figure 1 - Regional View of Impacts Due to Allowable Emissions from Clifty Creek Station

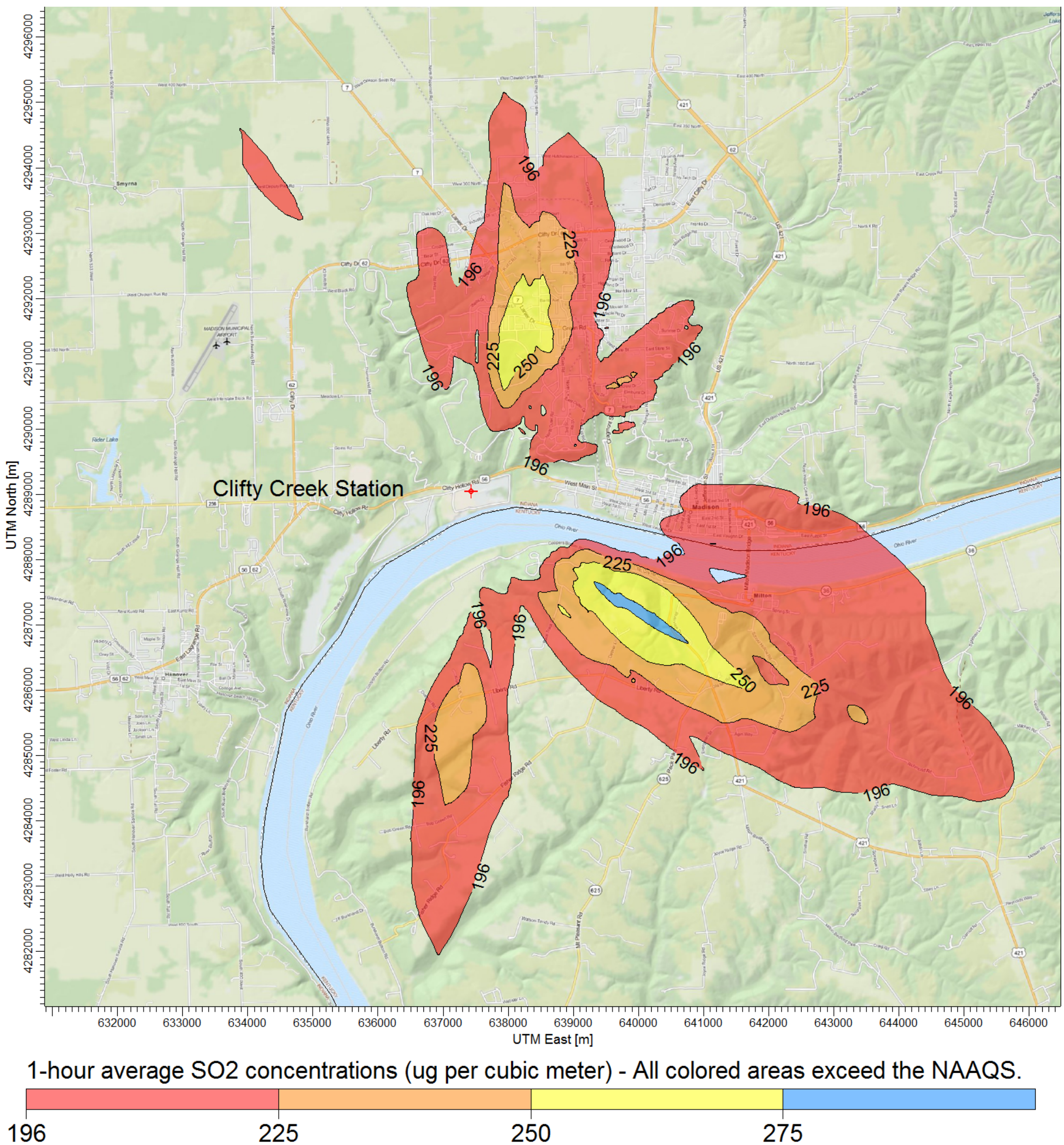

Figure 2 - Regional View of Impacts Due to Actual Emissions for the 2012-14 Period from All Sources

3. Modeling Methodology

3.1 Air Dispersion Model

The modeling analysis used USEPA's AERMOD program, v. 14134. AERMOD, as available from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website, was used in conjunction with a third-party modeling software program, *AERMOD View*, sold by Lakes Environmental Software.

3.2 Control Options

The AERMOD model was run with the following control options:

- 1-hour average air concentrations
- Regulatory defaults
- Flagpole receptors

To reflect a representative inhalation level, a flagpole height of 1.5 meters was used for all modeled receptors. This parameter was added to the receptor file when running AERMAP, as described in Section 4.4.

An evaluation was conducted to determine if the modeled facility was located in a rural or urban setting using USEPA's methodology outlined in Section 7.2.3 of the Guideline on Air Quality Models.[7] For urban sources, the URBANOPT option is used in conjunction with the urban population from an appropriate nearby city and a default surface roughness of 1.0 meter. Methods described in Section 4.1 were used to determine whether rural or urban dispersion coefficients were appropriate for the modeling analysis.

3.3 Output Options

The AERMOD analysis was based on three years of recent meteorological data. The modeling analyses used one run with three years of sequential meteorological data from 2012-2014. Consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations, AERMOD provided a table of fourth-high 1-hour SO_2 impacts concentrations consistent with the form of the 1-hour SO_2 NAAQS.[8]

Please refer to Table 1 for the modeling results.

---

[7] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.
[8] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 24-26.

4. Model Inputs

4.1 Geographical Inputs

The "ground floor" of all air dispersion modeling analyses is establishing a coordinate system for identifying the geographical location of emission sources and receptors. These geographical locations are used to determine local characteristics (such as land use and elevation), and also to ascertain source to receptor distances and relationships.

The Universal Transverse Mercator (UTM) NAD83 coordinate system was used for identifying the easting (x) and northing (y) coordinates of the modeled sources and receptors. Stack locations were obtained from facility permits and prior modeling files provided by the state regulatory agency. The stack locations were then verified using aerial photographs.

The facility was evaluated to determine if it should be modeled using the rural or urban dispersion coefficient option in AERMOD. A Geographic Information System (GIS) was used to determine whether rural or urban dispersion coefficients apply to a site. Land use within a three-kilometer radius circle surrounding the facility was considered. USEPA guidance states that urban dispersion coefficients are used if more than 50% of the area within 3 kilometers has urban land uses. Otherwise, rural dispersion coefficients are appropriate.[9]

USEPA's AERSURFACE v. 13016 was used to develop the meteorological data for the modeling analysis. This model was also used to evaluate surrounding land use within 3 kilometers. Based on the output from the AERSURFACE, approximately 11.6% of surrounding land use around the modeled facility was of urban land use types including Type 21 – Low Intensity Residential, Type 22 – High Intensity Residential and Type 23 – Commercial / Industrial / Transportation.

This is less than the 50% value considered appropriate for the use of urban dispersion coefficients. Based on the AERSURFACE analysis, it was concluded that the rural option would be used for the modeling summarized in this report. Please refer to Section 4.5.3 for a discussion of the AERSURFACE analysis.

[9] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005, Section 7.2.3.

4.2 Emission Rates and Source Parameters

The modeling analyses only considered SO_2 emissions from the Gibson, Trimble County, and Ghent facilities. Other off-site sources were not considered. Concentrations were predicted for the scenarios shown in Tables 1 and 2:

1) allowable emissions based on the current permit issued by the regulatory agency, and

2) actual hourly emissions measured each hour between January 1, 2012 and December 31, 2014 as taken from USEPA *Air Markets Program Data*.[10]

Stack parameters and emissions used for the modeling analysis are summarized in Table 4.

Table 4 – Facility Stack Parameters and Emissions [11]

Facility	Clifty Creek		Ghent			Trimble	
Stack	S13	S46	G01	G02	G04	T01	T02
Description	Units 1, 2 and 3	Units 4, 5 and 6	Unit 1	Units 2 and 3	Unit 4	Unit 1	Unit 2
X Coord. [m]	637424	637433.05	670779	670554	670479	638151	638155
Y Coord. [m]	4289051	4289043.51	4290835	4290716	4290646	4271869	4271865
Base Elevation [m]	143.21	143.06	147.94	147.82	148.8	146.38	146.34
Release Height [m]	299.31	299.31	201.78	176.78	201.78	231.65	231.65
Gas Exit Temperature [°K]	329.261	328.706	324.817	324.817	324.817	324.817	329.261
Gas Exit Velocity [m/s]	15.084	15.453	15.342	14.976	14.62	27.077	27.836
Inside Diameter [m]	9.504	9.504	8.077	15.941	8.077	5.486	6.279
Allowable Emission Rate [g/s]	5,313	5,313	-	-	-	-	-
Actual Emission Rate [g/s]	-	-	-	-	-	-	-

The above stack parameters and emissions were obtained from regulatory agency documents and databases identified in Section 2.2. The analysis was conducted based on 100% operating load using maximum exhaust flow rates and temperatures. Operation at less than full capacity loads was not considered. This assumption tends to under-predict impacts since stack parameters such as exit flow rate and temperature are typically lower at less than full load, reducing pollutant dispersion and increasing predicted air quality impacts. Stack location, height and diameter were verified using aerial photographs, and flue gas flow rate and temperature were verified using combustion calculations.

[10] http://ampd.epa.gov/ampd/
[11] Stack parameters were obtained from the annual survey compiled by the U.S. Energy Information Administration. http://www.eia.gov/electricity/data/eia860/

4.3 Building Dimensions

No building dimensions or prior downwash evaluations were available. Therefore this modeling analysis did not address the effects of downwash and this may under-predict impacts.

4.4 Receptors

For Clifty Creek Station, three receptor grids were employed:

1. A 100-meter Cartesian receptor grid centered on Clifty Creek Station and extending out 5 kilometers.
2. A 500-meter Cartesian receptor grid centered on Clifty Creek Station and extending out 10 kilometers.
3. A 1,000-meter Cartesian receptor grid centered on Clifty Creek Station and extending out 50 kilometers. 50 kilometers is the maximum distance accepted by USEPA for the use of the AERMOD dispersion model.[12]

A flagpole height of 1.5 meters was used for all these receptors.

Elevations from stacks and receptors were obtained from National Elevation Dataset (NED) GeoTiff data. GeoTiff is a binary file that includes data descriptors and geo-referencing information necessary for extracting terrain elevations. These elevations were extracted from 1 arc-second (30 meter) resolution NED files. The USEPA software program AERMAP v. 11103 is used for these tasks.

4.5 Meteorological Data

To improve the accuracy of the modeling analysis, recent meteorological data for the 2012-2014 period were prepared using the USEPA's program AERMET which creates the model-ready surface and profile data files required by AERMOD. Required data inputs to AERMET included surface meteorological measurements, twice-daily soundings of upper air measurements, and the micrometeorological parameters surface roughness, albedo, and Bowen ratio. One-minute ASOS data were available so USEPA methods were used to reduce calm and missing hours.[13] The USEPA software program AERMINUTE v. 14237 is used for these tasks.

This section discusses how the meteorological data was prepared for use in the 1-hour SO_2 NAAQS

---

[12] USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, Section A.1.(1), November 9, 2005.
[13] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, p. 19.

modeling analyses. The USEPA software program AERMET v. 14134 is used for these tasks.

4.5.1 Surface Meteorology

Surface meteorology was obtained for Louisville International Airport located near the Clifty Creek Station. Integrated Surface Hourly (ISH) data for the 2012-2014 period were obtained from the National Climatic Data Center (NCDC). The ISH surface data was processed through AERMET Stage 1, which performs data extraction and quality control checks.

4.5.2 Upper Air Data

Upper-air data are collected by a "weather balloon" that is released twice per day at selected locations. As the balloon is released, it rises through the atmosphere, and radios the data back to the surface. The measuring and transmitting device is known as either a radiosonde, or rawindsonde. Data collected and radioed back include: air pressure, height, temperature, dew point, wind speed, and wind direction. The upper air data were processed through AERMET Stage 1, which performs data extraction and quality control checks.

For Clifty Creek Station, the concurrent 2012-2014 upper air data from twice-daily radiosonde measurements obtained at the most representative location were used. This location was the Wilmington, Ohio measurement station. These data are in Forecast Systems Laboratory (FSL) format and were downloaded in ASCII text format from NOAA's FSL website.[14] All reporting levels were downloaded and processed with AERMET.

4.5.3 AERSURFACE

AERSURFACE is a program that extracts surface roughness, albedo, and daytime Bowen ratio for an area surrounding a given location. AERSURFACE uses land use and land cover (LULC) data in the U.S. Geological Survey's 1992 National Land Cover Dataset to extract the necessary micrometeorological data. LULC data was used for processing meteorological data sets used as input to AERMOD.

AERSURFACE v. 13016 was used to develop surface roughness, albedo, and daytime Bowen ratio values in a region surrounding the meteorological data collection site. AERSURFACE was used to develop surface roughness in a one kilometer radius surrounding the data collection site. Bowen ratio and albedo was developed for a 10 kilometer by 10 kilometer area centered on the meteorological data collection site. These micrometeorological data were processed for seasonal periods using 30-degree sectors. Seasonal moisture conditions were considered average with winter

[14] Available at: http://esrl.noaa.gov/raobs/

months having continuous snow cover.

4.5.4 Data Review

Missing meteorological data were not filled as the data file met USEPA's 90% data completeness requirement.[15] The AERMOD output file shows there were 0.12% missing data.

To confirm the representativeness of the airport meteorological data, the surface characteristics of the airport data collection site and the modeled source location were compared. Since the Louisville International Airport is located close to Clifty Creek Station, this meteorological data set was considered appropriate for this modeling analysis. [16] This weather station provided high quality surface measurements for the most recent 3-year time, and had similar land use, surface characteristics, terrain features and climate. Finally, the meteorological data from the selected surface and upper air stations were recommended by the Indiana Department of Environmental Management for modeling facilities located in Jefferson County.[17]

5. Background SO_2 Concentrations

Background concentrations were determined consistent with USEPA's Modeling Guidance for SO_2 NAAQS Designations.[18, 19] To preserve the form of the 1-hour SO_2 standard, based on the 99th percentile of the annual distribution of daily maximum 1-hour concentrations averaged across the number of years modeled, the <u>background</u> fourth-highest daily maximum 1-hour SO_2 concentration was added to the <u>modeled</u> fourth-highest daily maximum 1-hour SO_2 concentration.[20] Background concentrations were based on the 2011-13 design value measured by the ambient monitors located in Indiana.[21]

6. Reporting

All files from the programs used for this modeling analysis are available to regulatory agencies. These include analyses prepared with AERSURFACE, AERMET, AERMAP, and AERMOD.

---

[15] USEPA, Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-05, February 2000, Section 5.3.2, pp. 5-4 to 5-5.
[16] USEPA, AERMOD Implementation Guide, March 19, 2009, pp. 3-4.
[17] Indiana DEM, Air Dispersion Meteorological Data, http://www.in.gov/idem/airquality/2376.htm
[18] USEPA, Area Designations for the 2010 Revised Primary Sulfur Dioxide National Ambient Air Quality Standards, Attachment 3, March 24, 2011, pp. 20-23.
[19] USEPA, SO_2 NAAQS Designations Modeling Technical Assistance Document, Dec. 2013, section 8.1, pp 27-28.
[20] USEPA, Applicability of Appendix W Modeling Guidance for the 1-hour SO_2 National Ambient Air Quality Standard, August 23, 2010, p. 3.
[21] http://www.epa.gov/airtrends/values.html